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Image coding method and image coding apparatus

Abstract:

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In high efficiency coding of motion image signal in transmission or recording of the motion image signal, plural predict signals are determined by independently compensating a motion of reproduction signals of plural frames positioned before a frame to be coded. A linear combination of these predict signals is used as a predict signal. An error of the frame to be coded and the predict signal is coded. As a result, the distortion of the predict signal, that is, the predict error is reduced, and the coding efficiency is enhanced.

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(54) Image coding method and image coding apparatus.

(57) In high efficiency coding of motion image signal in transmission or recording of the motion image signal, plural predict signals are determined by independently compensating a motion of reproduction signals of plural frames positioned before a frame to be coded. A linear combination of these predict signals is used as a predict signal. An error of the frame to be coded and the predict signal is coded. As a result, the distortion of the predict signal, that is, the predict error is reduced, and the coding efficiency is enhanced.

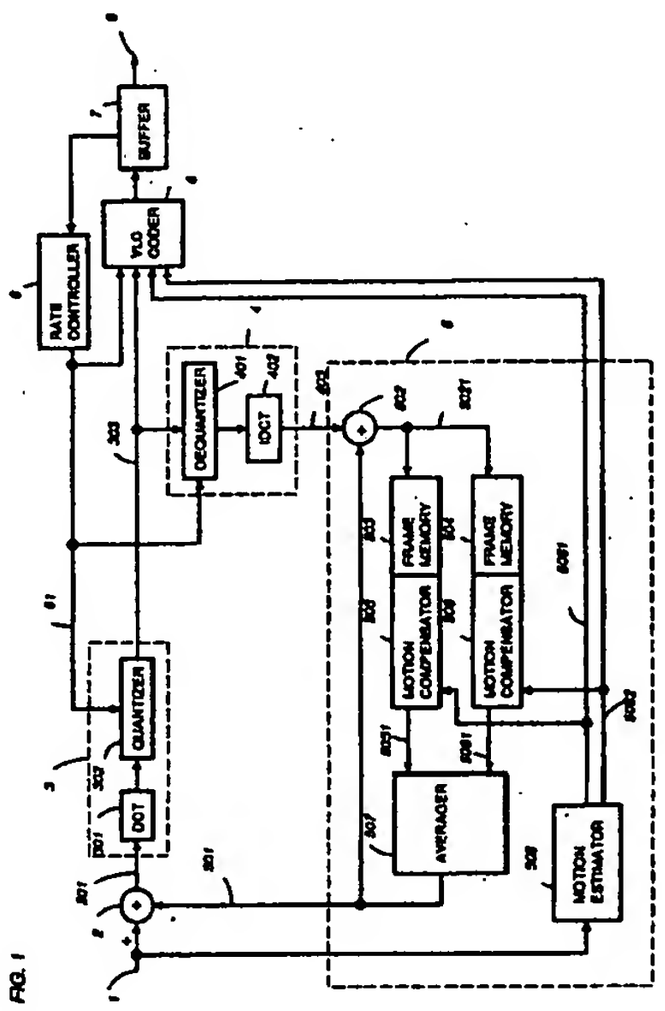

FIG. 1

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The present invention relates to an image coding method for high efficiency coding of motion image signals in transmission or recording of motion image signals and an apparatus for performing the method.

In the image coding apparatus, recently, along with the development of television telephone and television conference system, various high efficiency coding technologies have been realized. In particular, the coding technology making use of the inter-frame predict coding is widely used in the image coding apparatus.

The inter-frame predict coding system is to determine a predict signal by predicting a frame to be encoded from another frame, and encode a predict error which is a difference between the frame to be encoded and the predict signal. The predict signal is determined in the following manners. (1) A reproduction signal of a frame before the intended frame to be encoded is delivered from a memory of a local decoder, and it is compensated for motion to obtain a predict signal. (2) A reproduction signal of a frame before the intended frame to be encoded and a reproduction signal of a frame after the intended frame are delivered from memories of a local decoder, and after they are compensated for motion, a mean value of them is determined as a predict signal.

In the method of (2), in other words, a frame located between two reproduction signals apart from each other by two frames or more is determined by motion compensating frame interpolation, and this frame is used as the predict signal. One of the prior arts of such image coding apparatus is disclosed in EP90304841. The conventional image coding apparatus is explained below.

The motion picture signals entering the image coding apparatus are subjected to two types of predict methods alternately on a frame by frame basis. The predict method is the manner of determining the predict signal. The first predict method is to read the reproduction signal two frames before from a frame memory of a local decoder, and compensate it for motion to obtain a predict signal, and the second predict method is to determine an image signal by motion compensating frame interpolation from preceding and succeeding reproduction frames as a predict signal. Afterwards, a predict error signal is determined which is a difference between the frame to be encoded and the predict signal, and an encoded predict error signal is the output signal of the image coding apparatus. The image coding apparatus, possessing a local decoder, decodes the code, determines the reproduction image, and stores it in a frame memory.

In such constitution, however, a reproduction frame later in time is needed when determining the predict signal from the reproduction frames before and after the frame to be coded, that is, the frame later in time must have been already coded. To realize this, it is necessary to change the time sequence of the frames of the motion picture signals entering the coding apparatus, and therefore the constitution of the coding apparatus is complicated.

It is hence a primary object of the invention to raise the coding efficiency by reducing the distortion of predict signal, and to simplify the constitution of the coding apparatus.

To achieve the above object, the invention presents an image coding method comprising the steps of compensating a motion of reproduction signals of N (N being an integer of 2 or more) frames positioned before a frame to be coded to obtain first to N-th predict signals, determining a linear combination of the first to N-th predict signals to obtain a predict signal, and coding a difference of the frame to be coded and the predict signal.

The invention also presents an image coding apparatus comprising coding means for coding a difference of a frame to be coded and a predict signal to produce a predict error code, decoding means for decoding the predict error code to obtain a reproduction signal, memory means for storing the reproduction signal, motion compensating means for compensating a motion of N (N being an integer of 2 or more) frames before the frame to be coded in the reproduction signal stored in the memory means to obtain first to N-th predict signals, and linear combining means for determining a linear combination of the first to N-th predict signals to obtain the predict signal.

Being thus composed, the invention is capable of determining N predict signals by compensating the motion of the reproduction signals of N frames preceding the frame to be coded, and determining the predict signal by linear combining of these predict signals, so that the distortion of predict signal can be reduced. As a result, the predict error signal becomes small, and the coding efficiency is improved.

Fig. 1 is a block diagram of an image coding apparatus in a first embodiment of the invention.

Fig. 2 is an explanatory diagram showing the relation between the frame of motion image signal to be coded, and a frame of reproduction signal used for determining a predict signal, in the image coding apparatus of the first embodiment of the invention.

Fig. 3 is a timing chart of the image coding apparatus of the first embodiment of the invention.

Fig. 4 is a block diagram of image coding apparatuses in second and third embodiments of the invention.

Fig. 5 is an explanatory diagram showing the relation between a frame of moving image signal to be coded, and a frame of reproduction signal used for determining a predict signal, in the image coding apparatus of the third embodiment of the invention.

Referring now to the drawings, an embodiment of an image coding apparatus of the invention is described in detail below. Fig. 1 is a block diagram of an image coding apparatus in a first embodiment of the in-

vention. In Fig. 1, numeral 1 denotes an input of the image coding apparatus, 2 is a predict error calculator, 3 is a coder, 4 is a decoder, 5 is a predict signal calculator, 6 is a variable length coder, 7 is a buffer memory, 8 is a rate controller, and 9 is an output of the image coding apparatus.

Numeral 301 is a discrete cosine transform (DCT) circuit, and 302 is a quantizer, which are combined to compose the coder 3. Numeral 401 is a dequantizer, and 402 is an inverse discrete cosine transform (IDCT) circuit, which are combined to compose the decoder 4. Numeral 502 is an adder, 503 is a first frame memory, 504 is a second frame memory, 505 is a first motion compensator, 506 is a second motion compensator, 507 is an averager, and 508 is a motion estimator, which are combined to compose the predict signal calculator 5.

Numeral 201 is a predict error signal produced by the predict error calculator 2, 303 is a predict error code produced by the coder 3, 403 is a reproduction predict error signal produced by the decoder 4, 501 is a predict signal produced by the predict signal calculator 5, 5021 is a reproduction signal produced by the adder 502, 5051 is a first predict signal produced by the first motion compensator 505, 5061 is a second predict signal produced by the second motion compensator 506, 5081 is a first motion vector produced by the motion estimator 508, 5082 is a second motion vector produced by the motion estimator 508, and 81 is the quantizing step size produced by the rate controller 8.

In the thus composed image coding apparatus, the operation is described below while referring to Fig. 1. The motion image signal to be coded is entered in the input 1 of the image coding apparatus, and is fed into the predict error calculator 2 and the predict signal calculator 5. The predict error calculator 2 determines a difference of the motion image signal to be coded and the predict signal 501, and produces the result as the predict error signal 201. The coder 3 receives the predict error signal 201, processes it by DCT (discrete cosine transform) in the DCT circuit 301, quantizes the obtained DCT coefficient value in the quantizer 302 according to the value of the quantizing step size 81, and produces the predict error code 303. The decoder 4 receives the predict error code 303, dequantizes it in the dequantizer 401 according to the value of the quantizing step size 81, processes the obtained DCT coefficient value by IDCT (inverse discrete cosine transform) in the IDCT circuit 402, and produces the reproduction predict error signal 403. The variable length coder 6 receives the quantizing step size 81, predict error code 303, first motion vector 5081, and second motion vector 5802, codes them in variable length, and writes the obtained data into the buffer memory 7. The data is read out of the buffer memory 7 at a specified rate, and produced into the output 9 of the image coding apparatus. The rate controller 8 controls the value of the quantizing step size 81 so that the amount of data remaining in the buffer memory 7 becomes a specified amount.

The predict signal calculator 5 is a circuit for obtaining the predict signal 501. The adder 502 adds the reproduction predict error signal 403 and predict signal 501, and produces the reproduction signal 5021. The reproduction signal 5021 is stored in the first frame memory 503 and second frame memory 504 alternately on a frame by frame basis. The first motion compensator 505 compensates the motion of the reproduction signal read out from the first frame memory by the first motion vector 5081, and produces the first predict signal 5051. The second motion compensator 506 compensates the motion of the reproduction signal read out from the second frame memory 504 by the second motion vector 5082, and produces the second predict signal 5061. The averager 507 determines an average of the first predict signal 5051 and second predict signal 5061, and produces the predict signal 501. The motion estimator 508 determines and produces a motion vector of the image signal to be coded. The motion estimator 508 determines the motion vector between the image signal to be coded and the reproduction signal read out from the first frame memory 503, and produces the first motion vector 5081. It also determines the motion vector between the image signal to be coded and the reproduction signal read out from the second frame memory 504, and produces the second motion vector 5082.

Explained next is the relation between the frame of the motion image signal to be coded and the frame of the reproduction signal used for determining the predict signal 501. Fig. 2 is an explanatory diagram showing the relation between the frame of motion image signal to be coded, and the frame of reproduction signal used for determining the predict signal 501, in which f(n-2) to f(n+3) denote the (n-2)-th (n+3)-th frames of image signals. Fig. 2 (a) shows a case of coding the frame f(n), in which the predict signal is determined by motion compensation of the frame f(n-2) and frame f(n-1) of reproduction signals. Fig. 2 (b) shows a case of coding the frame f(n+1), in which the predict signal is determined by motion compensation of the frame f(n-1) and frame f(n) of reproduction signals. Figs. 2 (c) and (d) show cases of coding the frame f(n+2) and frame f(n+3), respectively.

The operation timing of the image coding apparatus is described below while referring to Fig. 3. Fig. 3 shows the timing chart of the image coding apparatus. In Fig. 3, (a) is an input signal of the image coding apparatus, (b) is the reproduction signal written into the first frame memory 503, (c) is the reproduction signal given to the first motion compensator 505 from the first frame memory 503, (d) is the reproduction signal written into the second frame memory 504, (e) is the reproduction signal given to the second motion com-

pensator 506 from the second frame memory 504, and (f) Is the predict signal 501. Besides, fr(n) is a frame of reproduction signal obtained by coding and decoding the frame f(n) of input signal, and fp(N) is a frame of predict signal for coding the frame f(n) of input signal.

The reproduction signal 5021 is written into the first frame memory 503 and second frame memory 504 alternately on a frame by frame basis. When the frame f(n) is entered in the input 1 of the image coding apparatus as input signal, the frame fr(n-2) of reproduction signal is read out from the first frame memory 503, and the motion Is compensated by the first motion compensator 505, so that the first predict signal 5051 is obtained. At the same time, the frame fr(n-1) of reproduction signal is read out from the second frame memory 504, and the motion is compensated in the second motion compensator 506, so that the second predict signal 5061 is obtained. The averager 507 determines the average of the first predict signal 5051 and second predict signal 5061, and produces fp(n) as predict signal 501.

In this way, since the average of the first and second predict signals Is used as the predict signal, the distortions contained in the first and second predict signals and are low in correlation are reduced by determining the average of the two predict signals. Thus, the distortion of predict signal is decreased, that is, the predict error is reduced, so that the coding efficiency is improved.

In the first embodiment, meanwhile, the predict signal 501 was the average of two predict signals, that is, the first predict signal 5051 and second predict signal 5052. But instead, by compensating the motion of N (N being an integer of 2 or more) reproduction frames, the first to N-th predict signals can be determined, and the predict signal 501 can be obtained by a linear combination thereof.

In the first embodiment, moreover, the distance between the frame to be coded and the frame of the first or second predict signal is one or two frames, but this distance is not limitative.

A second embodiment of the invention is described below while referring to the accompanying drawings.

Fig. 4 is a block diagram of an image coding apparatus in the second embodiment of the invention. In Fig. 4, numeral 509 is a predlct mode decision circuit, 510 is a predict signal selector, 5071 Is a third predict signal produced by an averager 507, and 5091 is a predict mode signal produced by the predict mode decision circuit 509. What is different from the first embodiment shown in Fig. 1 is the composition of the predlct signal calculator 5 and the input of the predict mode signal 5091 in the variable length coder 6.

In the thus composed image coding apparatus, the operation is explained below while referring to Fig. 4.

The averager 507 determines an average of the first predict signal 5051 and second predict signal 5061, and produces the third predict signal 5071. The predict mode decision circuit 509 judges a smallest predict error out of the incoming first to third predict signals, and produces an index showing it as a predict mode signal 5091. The predict signal selector 510 selects one out of the first predict signal 5051, second predict signal 5061, and third predict signal 5071, depending on the predict mode signal 5091, and produces a selected signal as the predict signal 501. The predict signal 541 is the one having the smallest predlct error out of the first to third predict signals. Besides, the predict mode signal 5091 is entered in the variable length coder 6, and is coded in variable length together with the quantizing step size 81, predict error code 303, first motion vector 5081, and second motion vector 5082.

Thus, according to the second embodiment, by installing the predict mode decision circuit and predict signal selector, the one having the smallest predict error out of the first to third predict signals Is used as the predict signal, so that the distortion of the predict signal can be reduced more as compared with the case of using the average of the first and second predict signals.

A third embodiment is explained below.

A block diagram of the third embodiment is the same as the second embodiment in Fig. 4. That is different from the second embodiment is that the motion image signal entering the input of the image coding apparatus is of interlaced scanning method. Fig. 5 is an explanatory diagram showing the relation between the frame of the motion image signal to be coded and the frame of reproduction signal used for determining the predict signal 501, in the image coding apparatus of the third embodiment of the invention. In the third embodiment, since the image signal to be coded is of interlaced scanning method, the n-th frame is composed of field f (n, 1) and field f (n, 2). Fig. 5 (a) shows a case of coding the field f(n, 1), in which the predict signal is determined by motion compensation of the field f(n-1, 1) and field f(n-1, 2) of reproduction signal. Fig. 5 (b) shows a case of coding the field (n, 2), in which the predict signal Is determined by motion compensation of the field f(n-1, 1) and field f(n-1, 2) of reproduction signal. Figs. 5 (c) and (d) show cases of determining the field f(n+1, 1) and field f(n+1, 2).

Thus, also when the motion image signal of interlaced scanning method is coded by the coding apparatus in the third embodiment, the distortion of the predict signal can be reduced in the same way as in the second embodiment. Furthermore, since the first predict signal and second predict signal are reproduction signals which are different from each other in the type, an efficient prediction is realized for a moving image signal.

In the third embodiment, the two fields used for

determining the predict signal belong to one same field, but the two fields may also belong to different fields.

In the third embodiment, moreover, the distance between the frame to be coded and the frame of the first or second predict signal is one frame, but this distance is not limitative.

Claims

1. An image coding method comprising the steps of:
compensating a motion of reproduction signals of N (N being an integer of 2 or more) frames positioned before a frame to be coded to obtain first to N-th predict signals;
determining a linear combination of the first to N-th predict signals to obtain a predict signal; and
coding a difference of the frame to be coded and the predict signal.

2. An image coding method comprising the steps of:
compensating a motion of reproduction signals of two frames positioned before a frame to be coded to obtain a first predict signal and a second predict signal;
determining an average of the first predict signal and the second predict signal to obtain a predict signal; and
coding a difference of the frame to be coded and the predict signal.

3. An image coding method comprising the steps of:
compensating a motion of reproduction signals of two frames positioned before a frame to be coded to obtain a first predict signal and a second predict signal;
determining an average of the first predict signal and the second predict signal to obtain a third predict signal;
determining a size of a predict error of the first, second and third predict signal in each block composed of a set of plural pixels;
selecting one having a smallest predict error out of the first, second and third predict signals to obtain a predict signal; and
coding a difference of the frame to be coded and the predict signal.

4. An image coding method comprising the steps of:
compensating a motion of reproduction signals of two frames positioned before a frame to be coded to obtain a first predict signal and a second predict signal;
determining an average of the first predict signal and the second predict signal to obtain a third predict signal;
selecting one out of two or more predict signals including the third predict signal to obtain a predict signal; and
coding a difference of the predict signal and the frame to be coded.

5. An image coding apparatus comprising:
coding means for coding a difference of a frame to be coded and a predict signal to produce a predict error code;
decoding means for decoding the predict error code to obtain a reproduction signal;
memory means for storing the reproduction signal;
motion compensating means for compensating a motion of N (N being an integer of 2 or more) frames before the frame to be coded in the reproduction signal stored in the memory means to obtain first to N-th predict signals; and
linear combining means for determining a linear combination of the first to N-th predict signals to obtain the predict signal.

6. An image coding apparatus comprising:
coding means for coding a difference of a frame to be coded and a predict signal to produce a predict error code;
decoding means for decoding the predict error code to obtain a reproduction signal;
memory means for storing the reproduction signal;
motion compensating means for compensating a motion of N (N being an integer of 2 or more) frames before the frame to be coded in the reproduction signal stored in the memory means to obtain first to N-th predict signals;
linear combining means for determining a linear combination of the first to the N-th predict signals to obtain a predict signal of a linear combination; and
selector means for selecting one out of two or more predict signals including the predict signal of linear combination to obtain the predict signal.

7. An image coding apparatus comprising:
predict error calculating means for producing a difference of a frame to be coded and a predict signal as a predict error signal;
coding means for coding the predict error signal to produce a predict error code;
decoding means for decoding the predict error code to obtain a reproduction signal;
memory means for storing the reproduction signal;
compensating means for compensating a motion of two frames positioned before the frame to be coded in the reproduction signal stored in

the memory means to obtain a first predict signal and a second predict signal;

averaging means for determining an average of the first predict signal and the second predict signal to obtain a third predict signal; and

predict error calculating means for determining a size of a predict error of the first, second and third predict signals in every block which is a set of plural pixels; and

means for selecting one having a smallest predict error out of the first, second and third predict signals as the predict signal.

8. An image coding apparatus comprising:

predict error calculating means for producing a difference of a frame to be coded and a predict signal as a predict error signal;

coding means for coding the predict error signal to produce a predict error code;

decoding means for decoding the predict error code to obtain a reproduction signal;

memory means for storing the reproduction signal;

compensating means for compensating a motion of two frames positioned before the frame to be coded in the reproduction signal stored in the memory means to obtain a first predict signal and a second predict signal;

averaging means for determining an average of the first predict signal and the second predict signal to obtain a third predict signal; and

selector means for selecting one out of two or more predict signals including the third predict signal to obtain the predict signal.

9. An image coding apparatus for coding a motion image signal of interlaced scanning method, comprising:

predict error calculating means for producing a difference of a field to be coded and a predict signal as a predict error signal;

coding means for coding the predict error signal to produce a predict error code;

decoding means for decoding the predict error code to obtain a reproduction signal;

memory means for storing the reproduction signal;

motion compensating means for compensating a motion of a first field and a second field positioned before the field to be coded in the reproduction signal stored in the memory means to obtain a first predict signal and a second predict signal;

averaging means for determining an average of the first predict signal and the second predict signal to obtain a third predict signal; and

predict error calculating means for determining a size of a predict error of the first, second and third predict signals in every block which is a set of plural pixels; and

means for selecting one having a smallest predict error out of the first, second and third predict signals as the predict signal.

10. An image coding apparatus for coding a motion image signal of interlaced scanning method, comprising:

predict error calculating means for producing a difference of a field to be coded and a predict signal as a predict error signal;

coding means for coding the predict error signal to produce a predict error code;

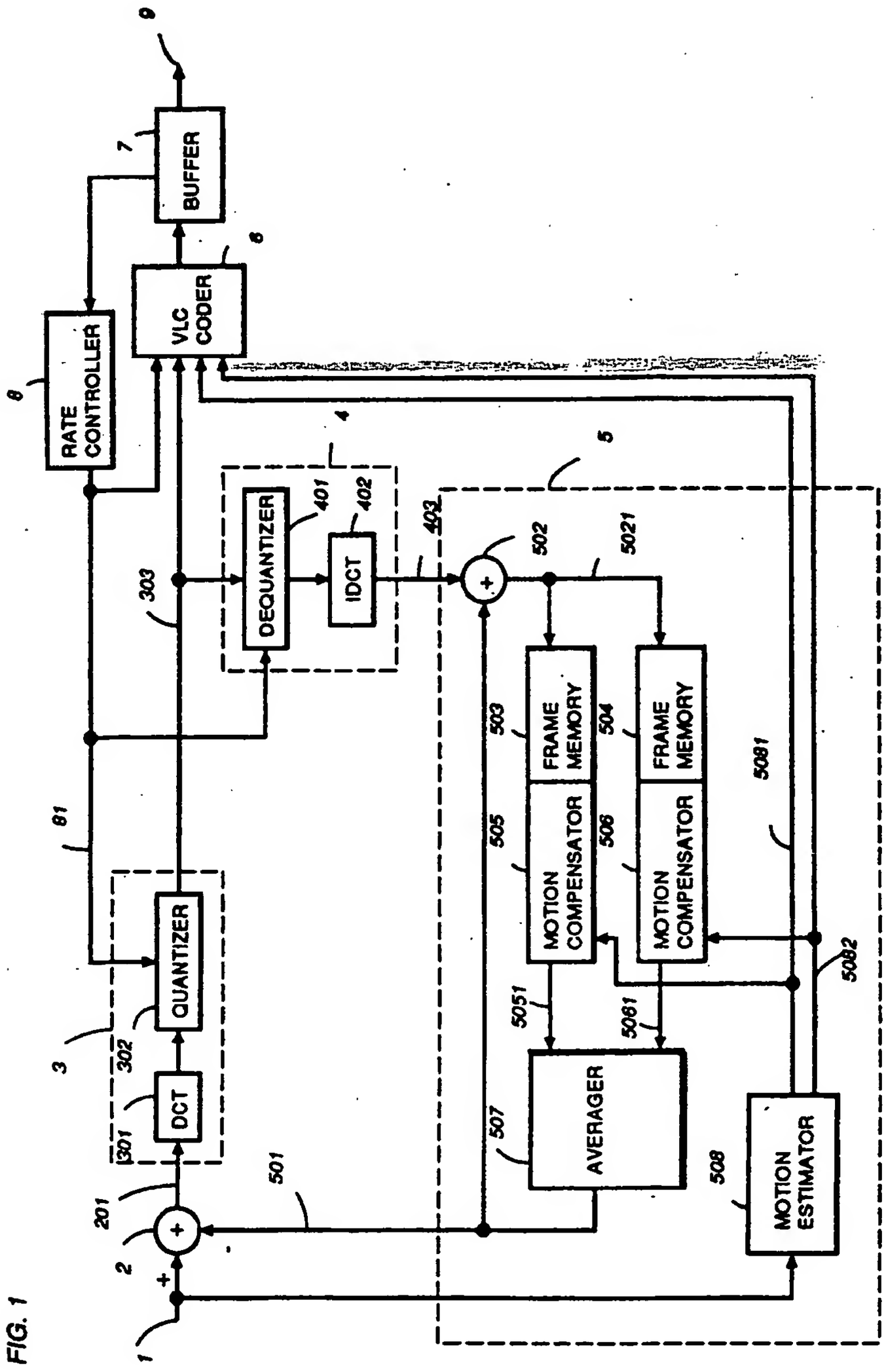
decoding means for decoding the predict error code to obtain a reproduction signal;

memory means for storing the reproduction signal;

motion compensating means for compensating a motion of a first field and a second field positioned before the field to be coded in the reproduction signal stored in the memory means to obtain a first predict signal and a second predict signal;

averaging means for determining an average of the first predict signal and the second predict signal to obtain a third predict signal; and

selector means for selecting one out of two or more predict signals including the third predict signal to obtain the predict signal.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VLC CODER
RATE CONTROLLER
DEQUANTIZER
IDCT
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FRAME MEMORY
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MOTION COMPENSATOR
AVERAGER
MOTION ESTIMATOR
QUANTIZER
DCT

FIG. 1

FIG. 2

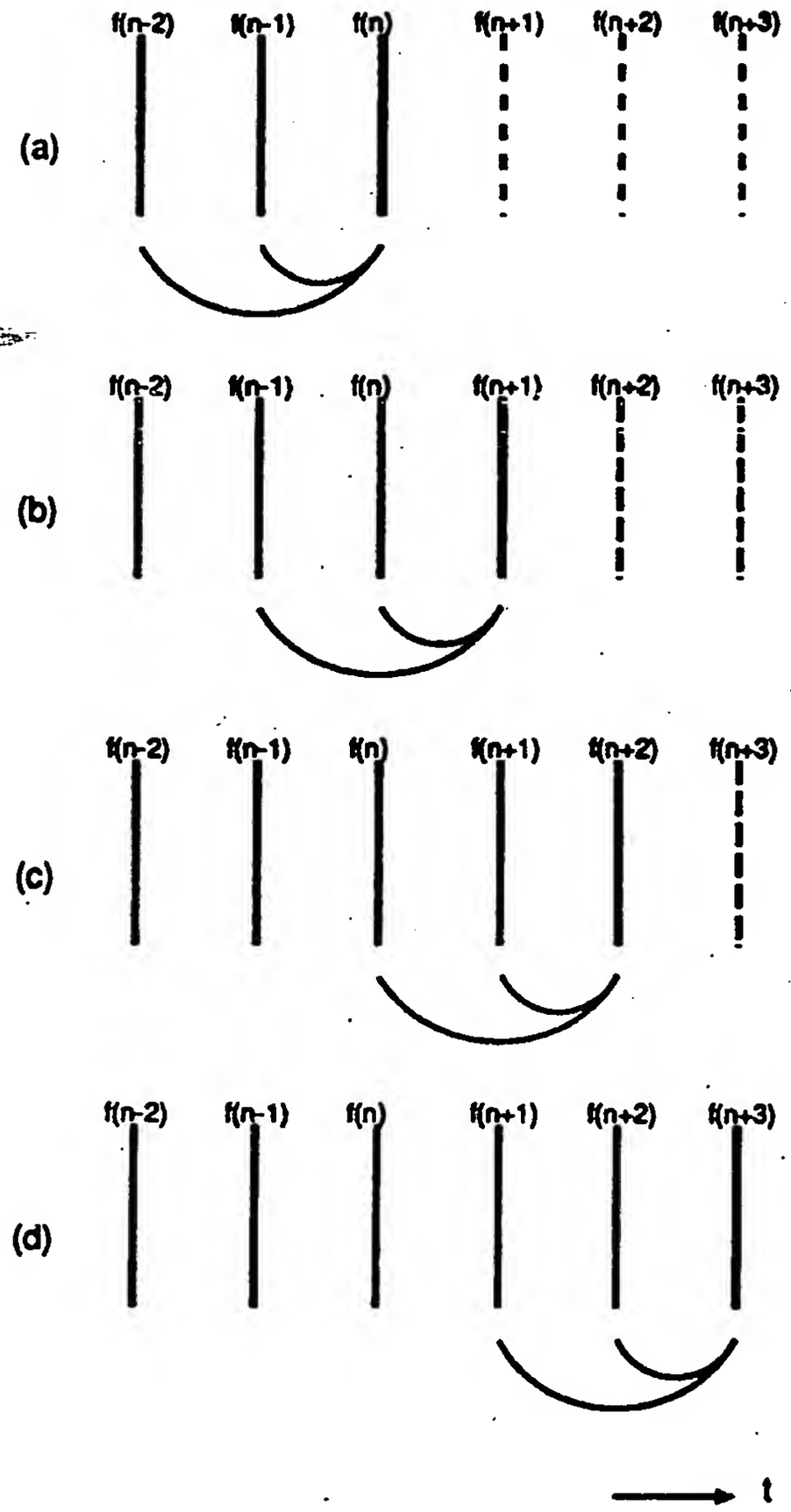
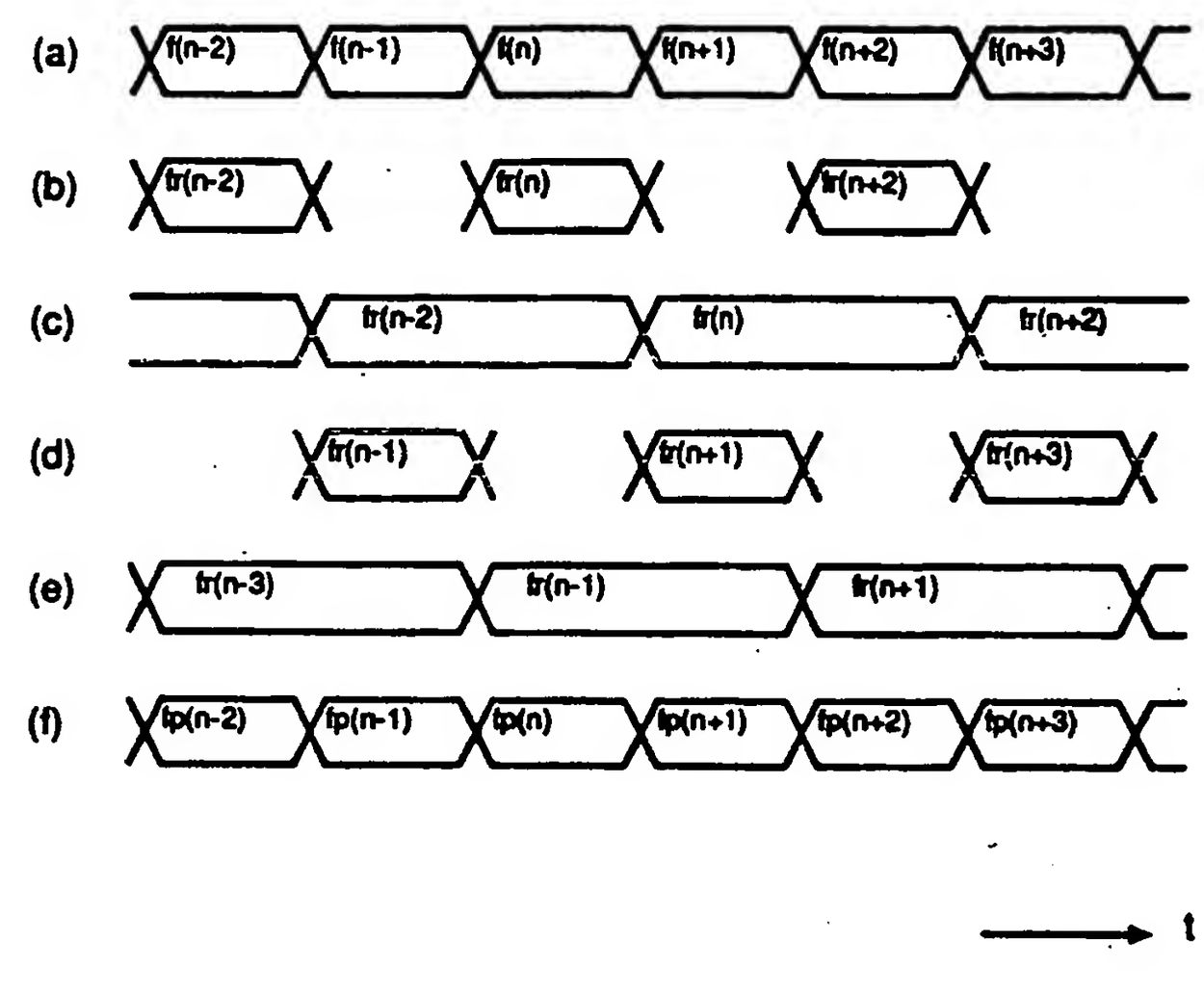


FIG. 3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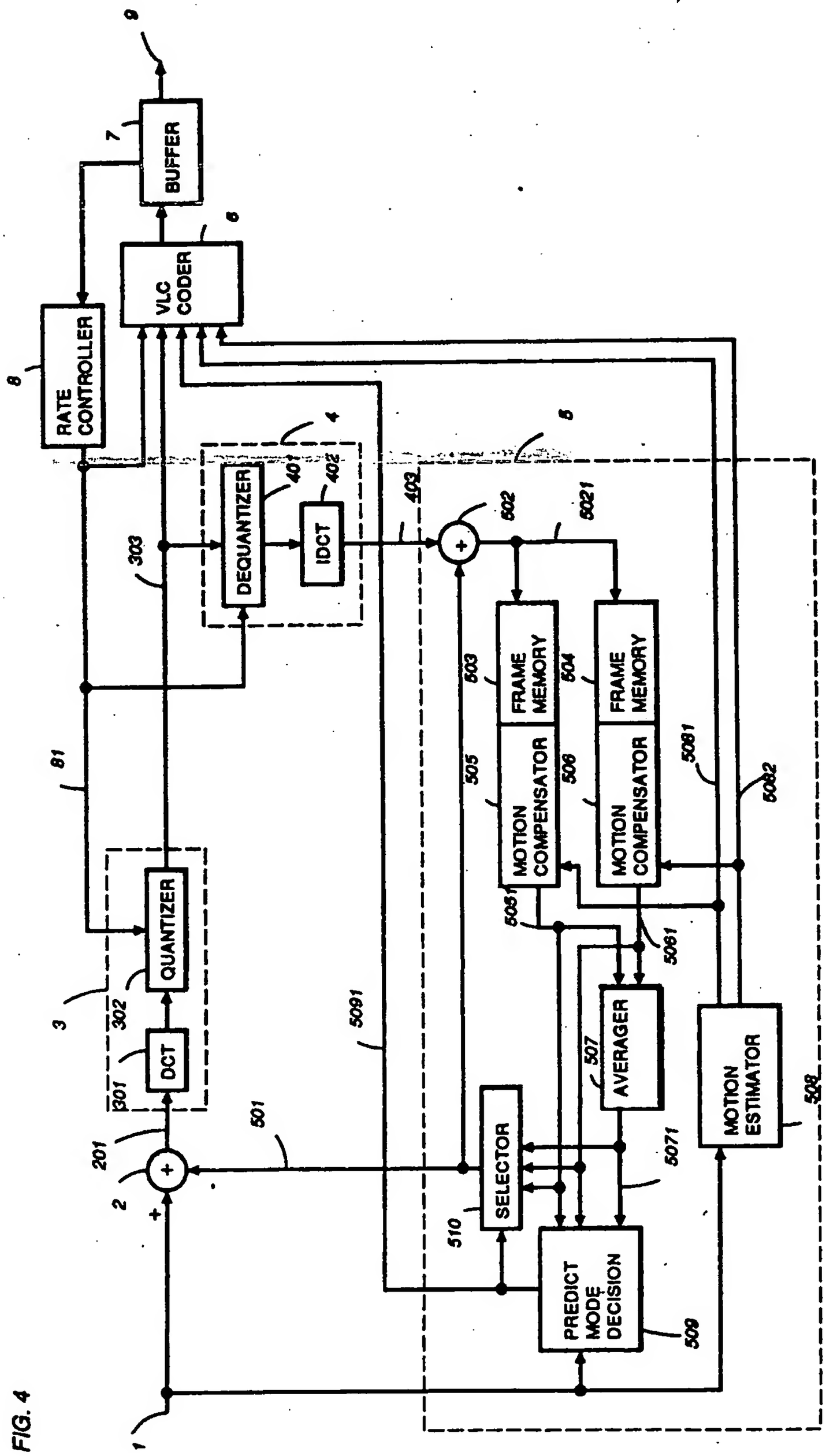
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BUFFER
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VLC CODER
8
RATE CONTROLLER
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DEQUANTIZER
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502
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FRAME MEMORY
503
504
505
506
MOTION COMPENSATOR
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5061
5081
5082
81
QUANTIZER
3
302
DCT
301
5091
501
AVERAGER
507
MOTION ESTIMATOR
508
201
2
SELECTOR
5071
510
PREDICT MODE DECISION
509
1

FIG. 4

FIG. 5